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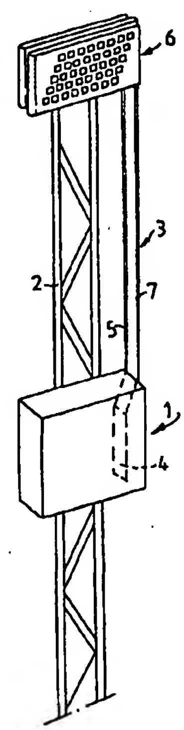
(54) Title: METHOD AND APPARATUS FOR COOLING HEAT-GENERATING ELECTRONIC COMPONENTS OF RADIO BASE STATIONS

(57) Abstract

Method and apparatus for cooling heat-generating electronic components of radio base stations installed at elevated locations, such as mast-mounted radio base stations (1). A thermosiphon cooling system (3), including a closed pipe circuit (5, 7) containing a self-circulating low-pressure generating refrigerant, and an evaporator (4) and a condenser (6), is used for cooling the heated components. The condenser (6) is constructed and mounted for natural convection of air therethrough at a summit portion of the pipe circuit outside and above the radio base station (1).



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Method and apparatus for cooling heat-generating electronic components of radio base stations

Technical field

The present invention relates to a method and an apparatus for cooling heat-generating electronic components of radio base stations installed at elevated locations, such as mast-mounted radio base stations.

Background of the invention

Previously known high power radio base stations are normally provided with motor-driven cooling fans for cooling the hot electronic components thereof. Due to the use of movable components, such as motor-driven fans or ventilators, such radio base stations become bulky and heavy and require regular maintenance. Therefore, radio base stations of the kind in question are mostly mounted at low locations (near the ground) for easy access thereto.

Thermosiphon cooling systems comprising a closed pipe circuit containing a self-circulating refrigerant and equipped with a lower evaporator and an upper condenser are well known for various general cooling purposes, wherein the refrigerant is brought into thermal contact with the heated parts to be cooled and thereby evaporates and flows to the upper condenser in which the vaporized refrigerant is condensated while emitting heat to the ambient air by means of cooling fins of the condenser. The condensated refrigerant then flows back to the evaporator due to higher density and gravity, and the process is then repeated automatically.

Previously known thermosiphon cooling systems usually operate with refrigerants generating high internal pressures in the closed pipe circuit. For example, when using ammonia as refrigerant, such high internal pressures as 30 bars may be generated in the system, which calls for very rigid structures of the condensers and frames holding the condenser parts together. Condensers of existing thermosiphon systems are also characterized by having long transport distances for the heat of the

condensated refrigerant to the ambient outdoor air, and they require condenser structures which have a less efficient surface/volume ratio. Such condensers often need to be cooled by forced air ventilation by means of motor-driven fans.

Summary of the invention

It is an object of the invention to provide an improved method and apparatus for a reliable and efficient cooling of heat-generating electronic components of outdoor radio base stations of minimized size and weight, thereby enabling elevated and remote installation thereof, such as on poles, radio masts, house walls, etc., and an improved coverage/power ratio, and this without need of movable components requiring maintenance.

For this purpose it is suggested in accordance with the present invention to use a maintenance-free thermosiphon cooling system especially developed and adapted for cooling electronic components of radio base stations of the kind mentioned above.

According to the invention, a low-pressure generating medium is used as refrigerant in the closed, self-circulating thermosiphon system, and the condenser is constructed and installed for obtaining an efficient natural convection of ambient air through channels or spaces defined by adjacent outer plate surfaces of the condenser, and thereby a highly efficient surface/volume ratio for natural convection. The specific features of the method and the apparatus of the present invention are set forth in the appended claims.

Brief description of the drawings

Fig. 1 is a schematic perspective view of a mast-mounted radio base station for a mobile communication system, equipped with a thermosiphon cooling system of the present invention;

Fig. 2 is a schematic elevational view of the inner surfaces of two elongate plate strips having inclined ribs (only a few are shown), and forming

the main body of a condenser according to an embodiment of the invention;

Fig. 3 is a schematic perspective view of a condenser body formed of assembled plate strips of Fig.1, and bent into meander-like loops;

Fig. 4 is a cross-sectional view taken along the line IV-IV in Fig. 5;

Fig. 5 is an elevational view of a condenser configuration according to Fig. 3 and illustrates partially an external trapezoid spacer member located inbetween adjacent loops;

Fig. 6 is a cross-sectional view of a bent end portion of a meander-shaped condenser having both internal and external spacer members formed integrally with the plate strips;

Fig. 7 is a schematic perspective view of another bending configuration of a condenser of the present invention;

Fig. 8 is a plan view of an embodiment similar to that in Fig. 7 but illustrating two helically wound condenser bodies threaded coaxially into one another;

Fig. 9 shows a section of a planar condenser body according to another embodiment of the condenser of the invention;

Fig. 10 is a view of the condenser as seen in the direction of the arrow C in Fig. 9; and

Fig. 11 is a view as seen in the direction of the arrow D in Fig. 9.

Description of embodiments of the invention

In Fig. 1, 1 generally denotes a radio base station for a mobile communication system mounted at a summit region of a mast 2. The radio base station 1 is provided with an inventive thermosiphon cooling system generally denoted 3 and comprising an evaporator 4 arranged in thermal contact with heated electronic components of the radio base station, to be cooled, a pipe 5 for leading an upflowing refrigerant vapour from the evaporator 4 to an upper condenser 6 constructed and arranged for natural convection of ambient air, and a pipe 7 for a return flow of refrigerant condensated in the condenser 6 to the evaporator 4. The evaporator 4, pipes 5 and 7

and the condenser 6 form a closed circuit for a low-pressure generating refrigerant which may self-circulate through the closed circuit in accordance with the general operating principle of a thermosiphon. A preferred low-pressure generating refrigerant for the thermosiphon cooling apparatus of the present invention is ethanol, which, when evaporated, generates a pressure in the order of about 0,6-1,00 bars, i.e. a sub-pressure. Another low-pressure refrigerant which may be used is isobutane, even though it generates a slight over-pressure of a few bars. With a low-pressure thermosiphon cooling system, the tension or stress exerted on the condenser plates will be minimized, and hence the condenser may be built with a correspondingly less strength.

Fig. 2 schematically illustrates two elongate strip-shaped condenser blanks 10,12 for a thermosiphon cooling system according to the invention. The blanks may consist of thin, surface-enlarging aluminum plates which are provided with ridge-shaped spacer members 14,16 for holding the plates 10,12 mutually separated a predetermined distance of a few millimeters when assembling the same before sealing the respective long and short side edges thereof to form a closed, flat tubular body configuration by means of a suitable fastening method, such as welding, brazing, etc. The inner spacer members 14,16 preferably cross each other in the flat tubular body. At least one 12 of the plates may be provided with upper and lower, longitudinal grooves or channels 17 allowing the refrigerant to flow in a gaseous or vaporized form between and along the plates 10,12. In lieu of ridge-shaped spacer members integrally formed in the plate strips, the internal spacer members may be formed as bosses impressed in the surface plates, as schematically shown in Fig. 1.

The plates 10,12 should have excellent thermal conduction and structural strength properties and have a thickness preferably less than about 1 mm so that the flat tubular body can be produced in a single continuous process. The flat tubular body 18 is provided with one or more upper inlets (indicated at the arrow A in Fig. 3) to be connected to the pipe 5 for the vaporized refrigerant from the evaporator 4 in the thermosiphon cooling circuit 3, and one or more lower outlets B (Fig. 3) for leading

the refrigerant condensated in the condenser 6 back to the evaporator 4 in the radio base station via the pipe 7.

In order to obtain a surface/volume-efficient configuration of the condenser 6 suitable for natural convection in a thermosiphon cooling system for cooling electronic components of mast-mounted radio base stations without use of fans or ventilators, the flat tubular body 18 is bent into a meander-shaped condenser configuration having a plurality of loops with opposite, parallel wall surface sections which are held mutually separated a certain distance which is optimized for natural convection by means of separate, external spacer members 20 of e.g. trapezoid profile, as is partially shown in Fig. 5. A suitable distance is about 10-40 mm, preferably about 15-20 mm. The spacer members 20 may be attached to the opposite surfaces of the flat tubular body 18 by brazing or other bonding process. The spacer members 20 also form surface-enlarging cooling fins which improve the thermal transfer to the ambient air. Owing to the surface-enlarging spacer members 20, the need of bent surface plates containing refrigerant is reduced. The distance a between adjacent oblique surfaces of the trapezoid spacer members 20 (Fig. 5) may be about 10-40 mm.

Another embodiment of a flat tubular body 18' for forming a condenser having integral internal and external spacer members is shown in Fig. 6. The tubular body 18' is formed by plate strips 10',12', having along the length thereof sections of alternative low ridges 14' facing in one direction, and high plate folds 22 facing in the other direction. When assembling the plate strips 10',12', the low ridges 14' will form the internal spacer members between the plate strips, while the high plate folds 22 form the external spacer members, which form surface-enlarging cooling fins and maintain a desired distance between the loops of the meander-shaped condenser body similar to the one shown in Fig. 3 and 5.

Alternatively, the condenser body of the thermosiphone cooling system of the present invention may be fomed by helical winding of the flat tubular body, such as

schematically shown in Fig. 7, where the condenser 6' is shown supported by a U-shaped retainer 24 fixated by brackets 26. An outer layer of the helically wound flat tubular body 18" is shown linearly extended and provided with internal spacer members 14" and upper and lower refrigerant ports A and B.

A particular volume-efficient assembly of the embodiment of Fig. 7 is shown in Fig. 8, where the helical winding is such that two (or more) helically wound flat tubular bodies 18" may be threaded coaxially within one another. In the embodiments of Fig. 7 and 8, external spacer members like those in Fig. 5 and 7 may be used.

The shape of the internal and external spacer members may be varied in many ways within the scope of the invention, as well as the configuration of the bending of the surface-enlarging flat tubular body. Thus, other configurations of zigzag or meander loops may be applied, wherein adjacent layers of the condenser body follow each other in parallel.

In Fig. 9-11 there is shown a further embodiment of the condenser 6", wherein two surface plates 10",12" are held fixated at a small mutual distance by means of two superimposed wave-shaped spacer elements 14",16", where the waves are square (or sinusoidal) and run transversely to one another, such as shown in Fig. 10 and 11.

In order to achieve best possible natural convection of air through the condenser, the surface plates thereof are orientated substantially vertically. The height of the condenser is preferably about 20-50 cm, and the distance between adjacent vertical outer surfaces of the flat tubular condenser chamber is about 10-40 mm, preferably about 15-20 mm.

A solar radiation protection shield (not shown) may surround the condenser so as to prevent the latter from being heated by solar rays. Such a protecting shield may also improve the natural convection of air through the condenser in that the shield

creates a chimney effect. In summary, in contrast to existing thermosiphon condensers comprising pipes with lamellae or frame with fins, the condenser of the present invention features a short heat transfer distance between the condensing gas and the ambient air, making it possible to use naturally cooled condensers also in hot climate zones, for cooling heat-generating electronic components of radio base stations. Thus, no motor-driven fans are required. Due to the fact that the thermo-siphon cooling system of the present invention operates with a low-pressure refrigerant, the forces acting on the condenser surface plates are minimized.

Claims

1. Method of cooling heat-generating electronic components of radio base stations (1) installed at elevated locations, such as mast-mounted radio base stations, comprising the step of cooling said components by means of a thermosiphon cooling system (3) including a closed pipe circuit (5,7) containing a self-circulating low-pressure generating refrigerant and equipped with a lower means (4) for evaporating the refrigerant when in thermal contact with the hot components to be cooled, and an upper condenser (6;6';6") for condensation of the evaporated refrigerant, and constructed and mounted for natural convection of air therethrough at a summit portion of the pipe circuit (5,7) outside and above the radio base station (1).

2. Method according to Claim 1, wherein ethanol is used as refrigerant.

3. Method according to Claim 1, wherein isobutane is used as refrigerant.

4. Apparatus for cooling heat-generating electronic components of radio base stations (1) installed at elevated locations, such as mast-mounted radio base stations, **characterized** by a thermosiphon cooling system (3) including a closed pipe circuit (5,7) containing a self-circulating low-pressure generating refrigerant and containing a lower means (4) for evaporating the refrigerant when in thermal contact with the hot components to be cooled, and an upper condenser (6;6';6") for condensation of the evaporated refrigerant, and constructed and mounted for natural convection of air therethrough at a summit portion of the pipe circuit (5,7) outside and above the radio base station (1).

5. Apparatus according to Claim 4, **characterized** in that the condenser (6;6';6") comprises at least one essentially flat tubular body (18;18';18") defined by a pair of closely separated, thin surface plates (10,12;10',12';10",12") orientated substantially vertically and folded or wound into a plurality of adjacent layers so

as to obtain a condenser configuration having a highly efficient surface/volume ratio for natural convection, said flat tubular body (18;18';18") having an upper inlet (A) for evaporated refrigerant and a lower outlet (B) for refrigerant condensed in the condenser.

6. Apparatus according to Claim 5, **characterized** in that the height of the condenser (6;6';6") is about 20-50 cm.

7. Apparatus according to Claim 4 or 5, **characterized** in that the distance between adjacent vertical outer surfaces of the flat tubular body is about 10-40 mm, preferably about 15-20 mm.

8. Apparatus according to anyone of Claims 5-7, **characterized** in that the flat tubular body is curved into meander-like loops having substantially parallel opposite surface plates.

9. Apparatus according to anyone of Claims 5-7, **characterized** in that the flat tubular body is curved into a helically wound condenser body (18").

10. Apparatus according to Claim 9, **characterized** in that the flat tubular body is helically wound with a pitch allowing for a correspondingly wound condenser body (18") to be coaxially threaded into it.

11. Apparatus according to anyone of Claims 5-10, **characterized** in that the surface plates (10,12;10',12') are held closely separated by internal spacer members (14,16;14';14") integrally formed in the plates.

12. Apparatus according to Claim 11, **characterized** in that the spacer members (14,16) are formed as ridges extending in an oblique angle relative to the flow direction of the refrigerant through the condenser (6).

13. Apparatus according to Claim 12, **characterized** in that the ridges (14) formed on the inner surface of the one surface plate (10) cross the ridges (16) formed on the opposite inner surface of the other plate (12).

14. Apparatus according to anyone of Claims 5-11, **characterized** in that the spacer members are formed as bosses impressed in the surface plates.

15. Apparatus according to anyone of Claims 5-14, **characterized** in that a solar radiation protecting shield surrounds the condenser.

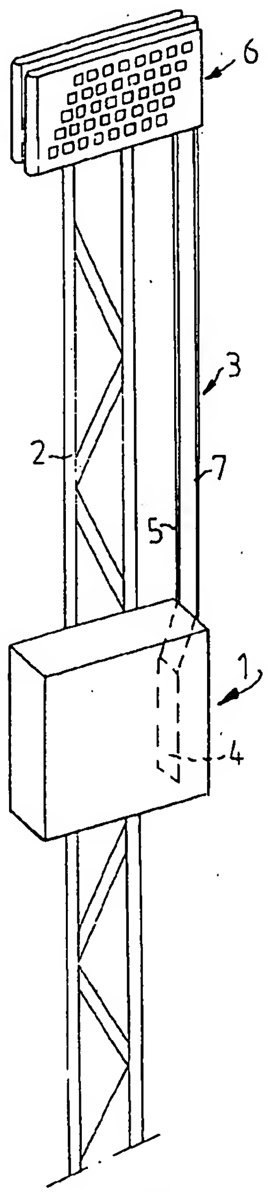

FIG.1

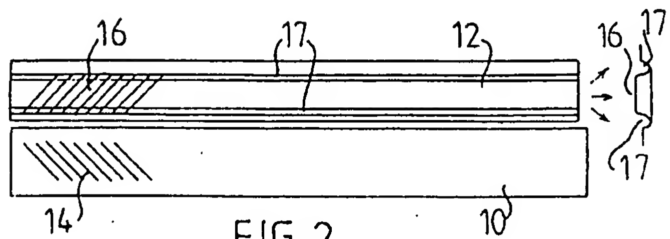

FIG. 2

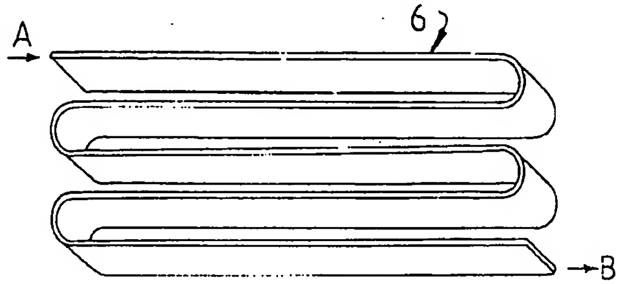

FIG. 3

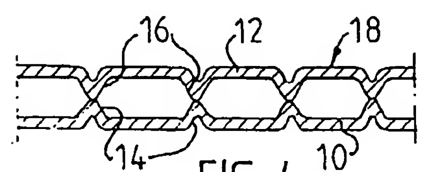

FIG. 4

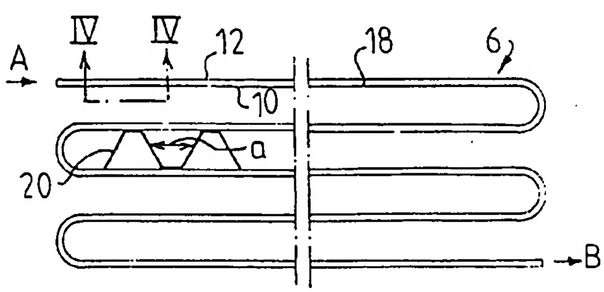

FIG.5

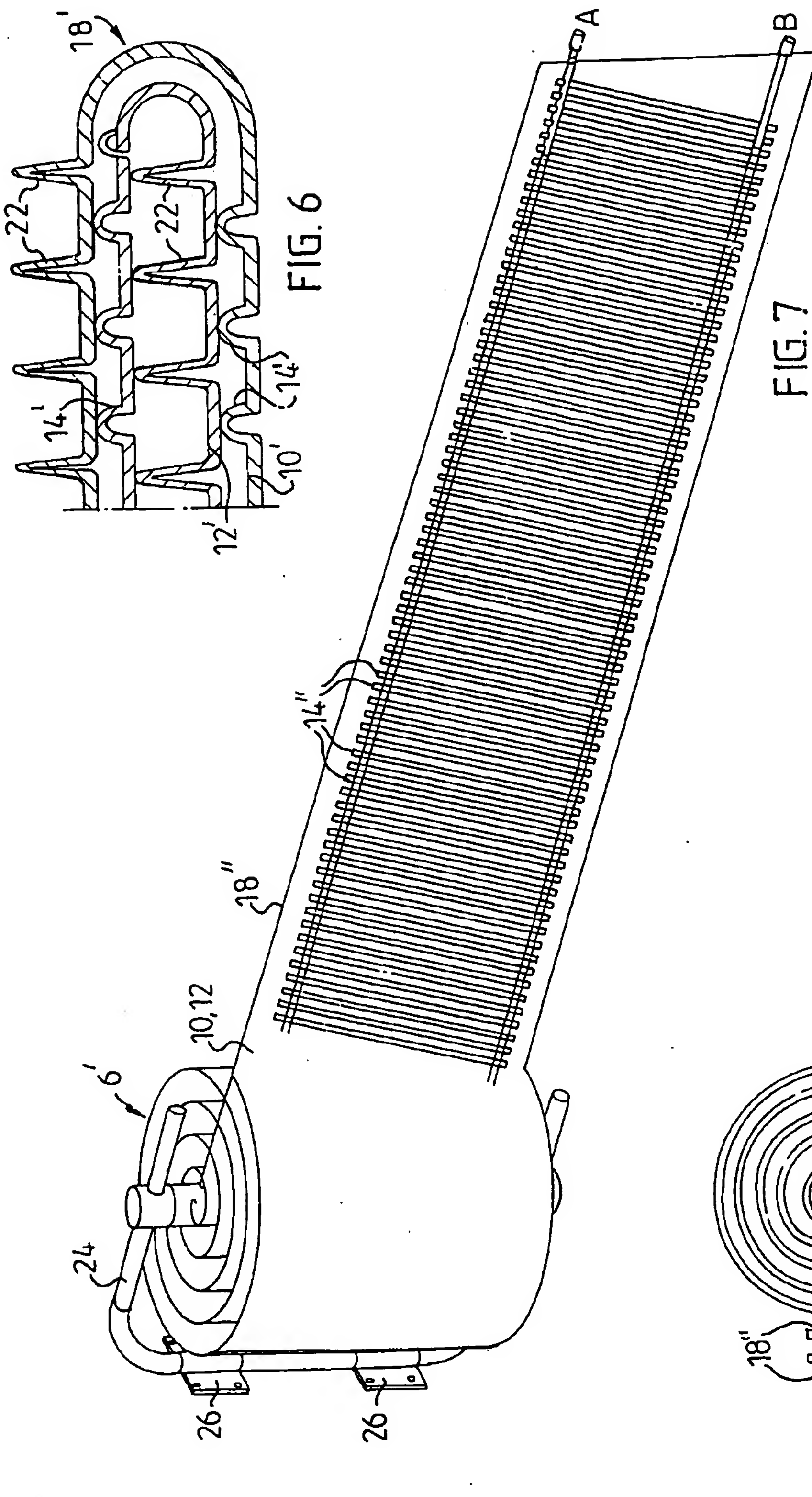

FIG. 6

FIG. 7

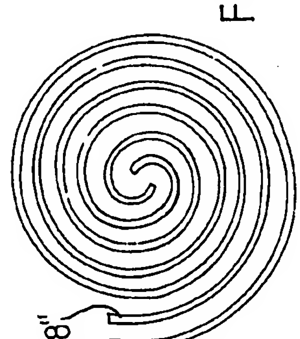

FIG. 8

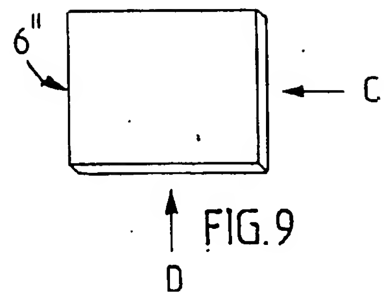

FIG.9

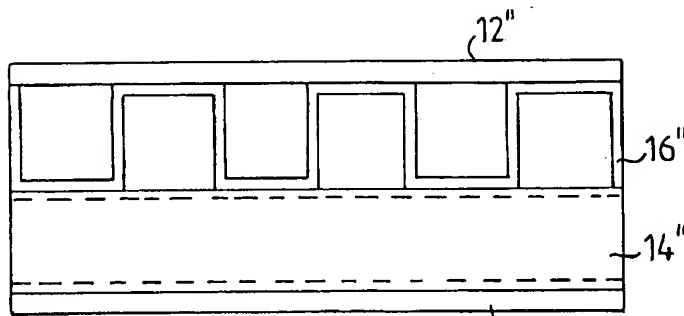

FIG. 10

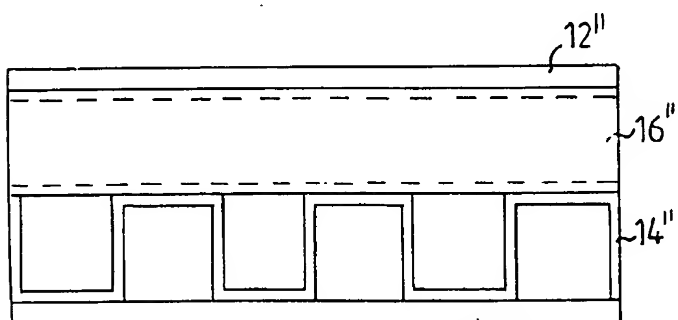

FIG.11

INTERNATIONAL SEARCH REPORT

International application No.
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A. CLASSIFICATION OF SUBJECT MATTER

IPC6: H04B 1/036, H05K 7/20, F28D 15/02, F25B 23/00

According to International Patent Classification (IPC) or to both national classification and IPC

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IPC6: F28D, F25B, H05K, H04Q, H04B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

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C. DOCUMENTS CONSIDERED TO BE RELEVANT

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